Development of ductile Cr-Re alloys for high temperature application in aggressive atmosphere

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The rhenium effect on the mechanical property enhancement of refractory metals has been the issue of several works since the mid 60's. This has led to the commercialisation of ductile Mo-Re and W-Re alloys for niche applications in the ultra-high temperature market. Despite their excellent mechanical properties, Mo-Re and W-Re alloys have the inconvenience of a very low oxidation resistance at high temperature. On the other hand, chromium offers the potential of a good oxidation resistance at high temperature. Whether rhenium alloying would have the same effects on Cr as on W and on Re without harming its intrinsic oxidation resistance is a topic of interest at the European Aeronautic Defence and Space Company (EADS) as ductile Cr-Re alloys would be ideally suited to cover a niche ultra-high temperature application market in case that their chemical properties were adequate.

The interest on Cr-Re alloys is not new, as the possibility of producing ductile, oxidation resistant Cr-Re alloys for aerospace applications was investigated intensely in the 70's and 80's at the Institute for Problems of Material Science in Kiev (IPMS). The work at IPMS on this topic was stopped in the mid 80's with promising but not definitive results. In 2002 collaboration contract between the EADS and the IPMS permitted to re-start the activities on Cr-Re alloys. This paper presents the results of a one-year research at the IPMS, the EADS and the UPC on the topic of Cr-Re alloys.

Up to date a manufacturing method for Cr-18at%Re and Cr-35at%Re has been developed by IPMS. Samples of these alloys have been characterized for mechanical properties at temperatures up to 1400°C and oxidation resistance to 1600°C. Results obtained to date show the outstanding mechanical and chemical properties of near solid solution Cr-Re alloys. As cast Cr-35at%Re alloys attain a room temperature compressive yield stress of 900 MPa and show good ductility. Moreover they present a compressive yield stress at 1400°C of 168 MPa. The weight gain after 4 hours exposure to air at 1600°C is low and corresponds to a metal recession of about 15µm (with a diffusion layer of 50µm), which is due to the increase in the interface stability with the passive oxide layer and the formation of a rhenium rich interface layer. Further work will include the determination of the alloy resistance to pure nitrogen atmosphere and the measurement of the thermal properties, thermal shock resistance and dilatation coefficients of the alloys.